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A Review of Photovoltaic Technologies in Solar Water Plant

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Abstract- Utilization of solar photovoltaic powered (PV) as a power source in water pumping systems has emerged as one of the valuable solar applications. Solar PV water pumping system (SPVWPS) is used to fulfill the demand of water in the field of irrigation and domestic use. This technology is recognized as a sustainable and environmentally friendly solution to provide water for domestic use and irrigation purpose. The tendency to use renewable energy resources has grown continuously over the past few decades, due to fear over warnings of global warming or because of the depletion and short life of fossil fuels or even as a result of the interest which has developed among researchers doing scientific research into it. This work can be considered as joining any of these groups with an objective of supplying drinking water and irrigation purposes to the society living in rural areas of the country as reported in the literature to serve as a quick reference to researchers and engineers who are interested in the subject. For further research perspective in the field of SPVWPS a few suggestions are recommended.

Keywords- Grid, Solar, Solar Energy, Solar Radiation, Solar power, Solar water pumping, photovoltaic, Irrigation.

I. INTRODUCTION

Water is the primary source of life for mankind and one of the most basic necessities for rural development. The Likelihood, it is possible to conclude that, there is no moment without this significant factor and (because of this) the rapidly increasing world population growth gives rise to a greatly increased demand for water and energy.

Most people in the world still lack access to basic water and energy services. In developing countries, generally composed of several villages sparsely located and with different topography, it is very difficult to extend the electric grid to every location where it is required.

In some areas of the countries the traditional water pumping systems powered by diesel or gasoline engines have been used for a long time, but fuel cost escalation, transportation problem, lack of skilled personnel make the conventional water pumping system unreliable and expensive for rural communities. Although a large amount of high-quality water is present in the world, often it is not available at locations where it can be readily used.

This raises the need to pump high-quality water from its source to the locations where it is in demand. For this purpose, water pumps have been in use for decades.

Nowadays, different researches have been carried out all over the world and their results show that, renewable energies are the best alternative energy sources to replace fossil energy.

Solar water pumping system is now emerging on the market and rapidly becoming more attractive than the traditional power sources. It is considered a promising solution to solve those challenged issues. It presents a clean source of supplying water for

irrigation with low maintenance required and with a reliable system that matches the generated energy with water needs for irrigation. Using solar water pumping in the remote area is environmental friendly; it has low running cost, long lifetime when compared to a diesel generator. Several renewable sources of energy can be used for water pumping.

However, solar photovoltaic (PV) turned out to be the suitable one. While being clean and naturally available, solar energy has been proved to have a direct relationship between its availability and water demand. The solar intensity is high in many locations where the electric grid does not reach and there is a high need for water (Aliyu et al., 2018).

Solar water pumping systems are an attractive application of renewable energy technology. The results suggest that photovoltaic water pumping systems are technically and economically feasible. Technical feasibility is determined from the maximum power required for pumping water and economic feasibility is determined by comparing present value cost of the photovoltaic and diesel pumping systems.

Also, the results of this study suggest that the price of the diesel fuel has increased within the last 10years to make the photovoltaic water pumping systems economically feasible, despite the initial costs of photovoltaic systems.

As the price of the solar panels decreases, the capital costs will decrease, making photovoltaic systems even more economically attractive [1]. The use of renewable energy is attractive for water pumping applications in remote areas of many developing countries (Shinde & Wandre, 2015).

PV system is based on semiconductor technology that converts sunlight into electricity. This is a proven technology but costs more than other electricity generation methods such as power plant based on coal, oil, natural gas and conventional hydro.

II. REALTED WORK

This paper establishes the flywheel energy storage organization (FESS) in a long lifetime uninterruptible power supply. The Flywheel Energy Storage (FES) system has emerged as one of the best options. This paper presents a conceptual study and illustrations of FES units. After brief introduction to the FES system and its theory of operation, the paper focuses on the important role of the FES system in enhancing the operation of the distribution network.

Supported by illustrated circuits, the FES system in the improvement of the power quality of the network [2] [3]. A flywheel energy storage technology was ended, with a special focus on the progress in automotive applications.

In order to improve the efficiency and lifetime, then it discusses a newly proposed design of the FES system that emerged recently, which includes the use of Superconducting Magnetic Bearings (SMB) and Permanent Magnetic Bearings (PMB).

In conclusion, the paper analyzes the FES systems great potentials that could be exploited in improving the reliability of the electrical system. [1]

The "smart grid" is a word used to describe the rapid infrastructure replacement of the electrical wiring system in the United States. When the advanced system is totally implemented, it will allow for communication features across the grids that are not currently available--hence the term "smart".

A ”smart grid” is simply an advanced electrical distribution system that has the capability to balance electrical loads from diverse, and often intermittent, alternative energy generation sources. In this paper the future trends for this issued development in power systems are assessed. Then the important evolution factors for developing the substations in the smart grid concept based on ICT (information & communication technology) are identified.

In terms of real-time communications and control functions, interactive between customers and markets, optimized to maximize reliability, availability, efficiency and economic performance secure from attack and naturally occurring disruptions. By this development, it can be provided advanced EMS (energy management system) and asset management within smart transmission grid.

The major theme of the paper is on the use of information technology to acquire more flexibility and smartness in the Wide Area Power System load Protection by designing the Communication channel using WIMAX.[2]

This paper analyzes the performance of the internal charge dynamics in high- voltage semiconductors, giving a clear base to understand the previously proposed zero-current-switching techniques for IGBT based resonant dual-active-bridges.

From these preceding approaches, the two most important concepts that consent to switching loss lessening in high voltage semiconductors are identified shaping of the conducted current in order to accomplish a high recombination time in the previously conducting semiconductors and achieving ZVS in the turning-on device. [3]

This paper presents maximum power tracking system .Maximum Power Point Tracking algorithms (MPPT) are employ to track maximum power, A DC-DC Boost converter is utilizing to acquire the impedance matching among the PV array and the load. The methods based on the perturb and observe (P&O) technique are the most frequently employed in commercial merchandise. The reason lies in the fact that P&O can be implemented in inexpensive digital devices with ensuring high toughness and a good MPPT efficiency.

This paper aims to presents the design and expansion of a photovoltaic system based on the improved P&O algorithm that consent to getting better efficiency, and design of effective charge controller with maximum power point tracker for photovoltaic system. Stability and accuracy of solar systems and the effectiveness of the proposed solar regulator system is verified by the simulation and experimental results under our developed system with MPPT algorithms [4]

PV water pumping systems: Photovoltaic (PV) power for irrigation is cost-competitive in comparison to traditional energy sources for small-scale water pumping requirements. With the continuous increase in fossil fuel cost and reduction in peak watt cost of solar cells due to mass production, the photovoltaic power is to become further economical in future.

PV powered water pumping systems have become attractive for livestock and agriculture applications in remote locations with limited access to conventional electricity. A number of studies have been carried out on performance evaluation, optimization, sizing techniques, efficiency improvement, and factors affecting system performance, economical and environmental aspects of PV pumping systems. The highlights of the research investigations are presented in this section.

Tamboli Kadar (2020) et.al Because of advances in agricultural technology, homestead equipment, ranch development, and office construction are all advancing at a rapid pace. Photovoltaic energy offers the advantages of being a clean, non-dirty power source that increases in intensity near the buyer and requires no maintenance.

This study proposes a solar-based photovoltaic (SPV) water siphoning system that will be made easier by a single-stage conveyance structure using an IMD (Induction Motor Drive) and a sharp power-sharing technique. The DC-to-DC converter serves as a network interface device as well as an adjustable force factor unit in SPV to IMD converters.

For the SPV cluster to be useful, the most severe force in the SPV exhibit must be removed. To help achieve this goal, a progressive conductance based on the highest force point after the control is applied. To regulate the IMD, however, a basic inverter voltage/recurrence control technique is used.

Bhim Singh (2018) et.al This study studies an efficient power transfer technique by using a solar photovoltaic (PV) array and a single-phase grid to supply a field-oriented-controlled (FOC) permanent-magnet synchronous motor (PMSM) drive for a water pumping system (WPS). Because of the intermittent nature of a single photovoltaic (PV) system, it is impossible to have a steady water supply. To help relieve this difficulty, a grid-intergraded WPS is offered below. Because of grid integration, the water pump may run continuously independent of the amount of solar insulation.

Furthermore, when water pumping is no longer required, PV electricity can be fed back into the utility grid. A voltage-source converter (VSC) and a voltage-source inverter are connected to a shared dc connection for utility grid and PMSM control.

To regulate the bidirectional power flow, a common dc connection connects a solar PV system to the utility grid, and a switching pulse is generated using unit vector template theory. A water pump and a sensor less FOC power the PMSM. A boost converter in the intermediate stage is used to extract the most

power from a solar PV array with changing insulation. The duty ratio for an MPP process can be computed using a perturb and observe approach.

The overall system's applicability, which includes the utility grid and a PV array fed by a PMSM-coupled water pump, is simulated in MATLAB/Simulink using the Sim Power System toolbox and validated on a laboratory prototype that adheres to the IEEE-519 standard for power factor and total harmonic distortion under varying solar insulation conditions and grid irregularities.

Apoorva Sharma (2021) et.al the motivation for developing this technology is to ensure continuous operation of a water pumping system regardless of solar insulation change. When PV power generated exceeds the required power for pumping, excess electricity can be transferred into the associated grid, and when PV power is insufficient to operate the pumping system, the grid supplies the remaining power required to operate the pumping system in a continuous way.

It improves the system's reliability, accuracy, and efficiency by enhancing the power quality. We have connected a voltage source converter for utility grid control and a voltage source inverter for PMS motor control to the dc link to create such a system. The unit vector template theory is used to govern the bidirectional power flow between the solar photovoltaic system and the associated grid.

A FOFE (fourth order fundamental extractor)-based control technique is employed in this study to filter contaminated grid voltage and estimate synchronizing components. For MPP tracking, the duty ratio for MPP operations is calculated using the incremental conductance technique. A less vector control technique is employed to control the speed of the PMS motor sensor. The suggested system is designed and tested in MATLAB/Simulink for a variety of scenarios.

Amarnath Yalavarthi (2020) et.al This work develops a medium-power solar water pump drive for small-scale irrigation and domestic energy supply, integrating sources like solar panels and grids with SR (Switched Reluctance) motor-pump and a set of consumer loads to assure communication and efficient operation. This drive system contains two converters. Inverters are classified into two types: those used to govern a switching reluctance motor (SRM) and those used to connect a single-phase grid. To get the greatest power from the PV array, the grid-side inverter control employs the MPP (Maximum Electricity Point) algorithm. To extract the critical load current component in PCC, an improved linear sinusoidal tracer (ILST) approach is used.

This algorithm was formerly used for active filtering. Among these benefits are the intrinsic benefits of PFC, such as harmonics reduction, high stability, and dynamic response. The drive is simulated using MATLAB/Simulink, and a laboratory prototype is developed to validate the results.

The system's reliability is tested under various abnormal conditions by introducing both source-side and load-side disruptions, and the results are displayed.

P.Niveditha (2021) et.al the purpose of this work is to create a single-stage solar water pumping system with a grid-interfaced switching reluctance motor and a PV control technique. Photovoltaic systems are significant as environmentally friendly energy sources due to their practicality and precedent. However, there are a few issues to consider.

As a result, there is a pressing need to produce as efficient photovoltaic power generating as possible. The most practical and cost-effective solution is to use equipment that tracks the position of the sun automatically.

Solar radiation and air temperature have an impact on voltage, current, and power characteristics, which in turn affect PV module performance. As a result, a Controller is required to reduce the impact and make the best use of the PV array's power. For tracking, a number of control systems are used, and solar-powered water pumping has recently come under attention.

In the current topic, the utility grid is combined with a switching reluctance motor. Other engines are unable to compete with SRM's market share. Grid-connected systems are in high demand due to their dependability, accuracy, and endurance.

MATLAB simulation was utilized to establish a simple control scheme and design for a PV-energized switching reluctance motor used in pumping

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applications, as solar technology has evolved dramatically.

III. SOLAR WATER PUMPING

PV water pumping systems have shown significant advancements in the last decade. The first generation PV pumping systems used centrifugal pumps usually driven by DC motors and variable frequency alternating current (AC) motors, with proven long-term reliability and hydraulic efficiency varying from 25% to 35%.

The second generation PV pumping systems use positive displacement pumps, progressing cavity pumps or diaphragm pumps, generally characterized by low PV input power requirements, low capital cost and high hydraulic efficiencies of even 70% The current solar pumping technology uses electronic systems which have further increased the output power, performance of the system and overall efficiency of the system.

The controller provides inputs for monitoring storage tank levels, controlling the pump speed and uses maximum power point tracking technology to optimize the water. Advancement has taken place in the tracking mechanism of PV arrays from manual tracking to dual axis automatic tracking systems by microcontroller programming. Tracking the sun reduces the physical size of PV panel area required for a given output, improves power yield, overall efficiency of the system and return on investment. Tracking of a solar pumping system extends the time for peak water yield.

The solar pumps available in the market can lift water from 5 m to more than 200 m with outputs of up to 250 m^3/day. For the past 15 years significant improvement has been done in helical motor pumps (positive displacement pumps) which are submersible and last for many years and are powered by similar motors as used for centrifugal pumps.

Advancement has been in the field of controllers for large size PV arrays in the order of 25 kW with 100 kW controllers expected to be developed in near future PV module costs have significantly declined and are available at a rate of US$ 0.59/Wp in 2014 as compared to around Types of solar water pumps: The various types of current configuration of direct coupled DC and AC solar water pumping systems being used worldwide are shown in

1. Water Supply Source:

Water supply source can be a pond, stream, spring, deep drilled well or a river. Water source must recharge faster than water pumping rate. In case pumping rate is faster than recharging rate of water source, the reservoir can dry which should be avoided to prevent damage to the pump. Main variables for system design are water reservoir volume, recharge rate and cost. PV generator: PV generator of a solar pump consists of PV modules connected in series and parallel combination as per motor voltage requirement. A PV module consists of solar cells which convert solar.

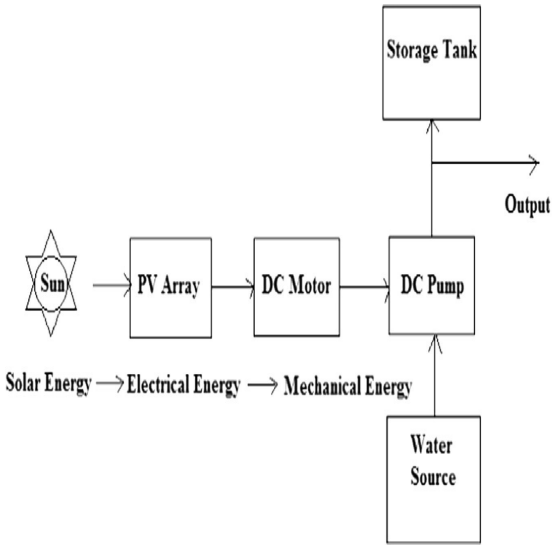

Fig 1. Block diagram of a direct coupled PV DC water pumping system.

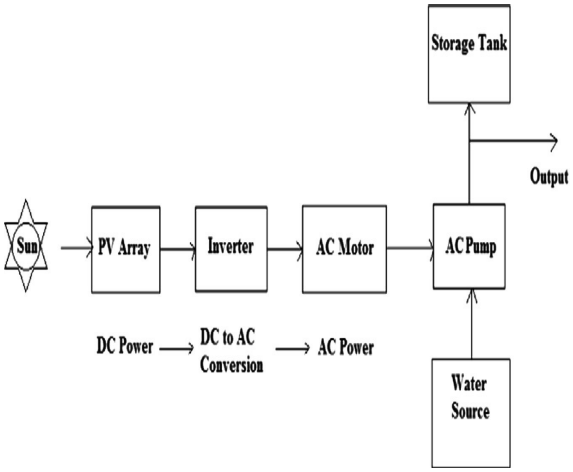

Fig 2. Block diagram of a PV AC water pumping system.

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Where I_L is light generated current, I_o is the diode reverse saturation current, a is the ideality factor which varies from 1 to5 and indicates solar cell characteristics deviation from ideal behavior, q is the charge on electron, k is the Boltzmann constant, T_c is the cell temperature, R_s is the series resistance and R_{sh} is the shunt resistance; R_{sh} has large value and R_s is small so it can be neglected in the analysis.

2. Solar pumps:

Solar water pumps are rated as per voltage supplied and require accessories like filters, float valves, switches, etc to function optimally. Solar pumps are constructed from high quality low lead marine grade bronze and stainless steel and are designed for corrosion-free and maintenance-free service even in harsh environment with long term performance and reliability.

Solar pumps are classified into three types according to their applications: submersible, surface, and floating water pumps. A submersible pump draws water from deep wells, and a surface pump draws water from shallow wells, springs, ponds, rivers or tanks, and a floating water pump draws water from reservoirs with adjusting height ability. The motor and pump are built in together in submersible and floating systems.

In the surface system, pump and motor can be selected separately to study the performance of system along with controller and PV panel. A pump produces a unique combination of flow and pressure i.e. high-flow/low-head to low-flow/high-head for a given power input.

Broadly, pumps can be classified under two categories based on operating principle: dynamic pumps and positive displacement pumps. Dynamic pumps operate by developing a high liquid velocity and pressure in a diffusing flow passage.

The efficiency of dynamic pumps is lower as compared to positive displacement pumps but have comparatively lower maintenance requirements. Positive-displacement pumps operate by forcing a fixed volume of from the inlet pressure section of the pump into the discharge zone of the pump.

These pumps generally tend to be larger than equal-capacity dynamic pumps. Centrifugal pumps and axial flow pumps are dynamic pumps [8].

IV. CONCLUSIONS

A review of current status of solar photovoltaic water pumping system technology research and applications is presented.

The study focuses on update on solar water pumping technology, performance analysis studies carried out worldwide, optimum sizing techniques, degradation of PV generator supplying power to pump, economic evaluation, environmental aspects and recent advances in materials and efficiency improvement of photovoltaic technology and experience of using solar PV pumps worldwide.

Based on the study main conclusions are as follows: PV water pumping technology is reliable and economically viable alternative to electric and diesel water pumps for irrigation of agriculture crops the technology further attractive alternative to diesel and electrical water pumping.

Factors affecting the performance and efficiency improving techniques, use of highly efficient PV modules including bifacial modules and degradation of PV generator are areas for further research for lowering the cost, improving the performance and enhancing pumping system life time.

Solar pumping is an attractive alternative for irrigation and rural, urban drinking water pumping applications in developing countries especially India, China, other Asian and African countries, keeping in view huge solar potential and the fact that significant rural population lives in the remote areas which requires water for drinking and irrigation of corps.

Water pumping for urban, rural and community water supplies and institutions, is another potential feasible sector but is not still widely utilized. The remote inaccessible locations with no grid electricity also need special attention.

These sectors still depend on conventional electricity or diesel based pumping system resulting in increased recurring costs to the users keeping in view the high installation costs of solar water pumps especially for large irrigation and water supplies, more incentives are required to be provided by governments to make.

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